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An Open Access Peer Reviewed Multidisciplinary Journal

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Editorial

A New Look For a Fresh Start

Abdeldjalil BENNECER

Although IBScientific may have had a face-lift, its mission to bring you a selection of the most exciting research findings in all areas of science, technology and arts remains the same.

As IBScientific enters its fourth year mid-April, the start of a new year is often a good time to embrace change and revisit the ways things are done, and it is just the same at this thriving knowledge enterprise. With this in mind, you will immediately notice that IBScientific website and the recent Journal of Science issue look somewhat different. Whether you are opening a print copy of the journal or reading its content online, you will see that our pages have undergone some substantial improvements. The main aim was to revitalise the design and publish issues in express format, which we have achieved by implementing an open journal archiving system, and providing useful tools for authors, reviewers, readers and librarians while removing unwanted white spaces and creating a new fresh look that presents information in a clearer and more concise fashion.

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The result is a journal with a look that is easier to read and navigate, a system that ensures a double-blind peer reviewed policy, and an archive that is much more accessible to harvest and search. We have also taken the opportunity to make a few other changes. To bring us in line with other IBScientific aims, we have adopted a new approach to guest reviews editing. As well as valuing contributions from experts and professionals who provide an in-depth insight into their topic, we also invited young, emerging researchers to be guest editors in their relevant areas of expertise. In this issue, Dr. A. Bouferrouk has kindly offered to take this role and together with his peers and IBScientific editors, they have reported a collection of review articles. For helicopter enthusiasts, various engineering designs to suit different applications, be it military or civil, are presented in the first review article which we hope will whet your appetite for finding out more about vertical take-off aircraft vehicles. In the second review article, high speed trains are explored in the context of a developing country like Algeria. This solution to modern congested – yet distant – urban cities, is usually technologically challenging and financially demanding in these parts of the world, but this is weighed against its benefits to solve transportation and environmental problems. We expect this topic to generate a variety of views and opinions which will add to the richness of the debate, and as it is accustomed in IBScientific, we welcome your contributions and we look forward to your letters.

Finally, although the appearance of the journal and the website may look different, we would like to reassure you that one of our core values – reporting research findings of the highest quality and complementing them with accessible articles that are of broad appeal to a wider audience – remain identical. Following the positive feedback on AIDS special issue (Vol 2, No 3), we have plans for several more focus issues in the future and we will also continue our programme of regular review articles throughout the year.

We are also engaged in organising a new IBScientific conference on a universal perspective on basic research in knowledge-based economy, to take place later this year. This will follow up from our previous conferences held in London in 2006 on the science and infrastructure in the developing world, and in 2007 conference held in Algiers in collaboration with FOREM about the role of knowledge from a socio-economic perspective. The website for the upcoming conference will be released soon, so watch out for updates on yet another exciting scientific event!!

Previews

The Intricacies of Rotorcraft Design

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Helicopters are a special type of aircraft which offer a wide range of civil and military applications. The essential feature is that it has rotating ?wings? or rotors. Compared with fixed-wing aircraft, the helicopter boasts unique capabilities including vertical take-off and landing (VTOL), the ability to hover near the ground (just like a hummingbird), and flying in different modes: forward (cruise), backward, climb, and sideways. Designing a rotorcraft with the ability to hover as well forward flight was the dream of many helicopter enthusiasts and not necessarily the result of some pressing operational needs. It is ironic, however, that this wide range of capabilities is the source for the many problems encountered in helicopter flight such as complex flow behaviour, strong vibrations and noise, challenging dynamics for stability and control, mechanical complexity, and an appetite for large power consumption. A distinct challenge for a helicopter is placed on its rotor which in addition to the need to provide vertical lift, it must also generate thrust and control. Nonetheless, the flying capabilities of helicopters make them extremely useful in many real life applications such as transport of executive, business and military personnel, rescue operations, lodging, fire fighting, heavy lifting, and so on.

When one compares helicopters to conventional fixed-wing aircraft, limitation on high speed flight for the former is a clear distinction. However, when the various functions a rotorcraft machine must fulfil are considered it becomes evident that the unique requirements of VTOL along with the ability to transform to and out of forward flight present considerable challenges for helicopter engineers. In particular, issues related to rotor blade efficiency for lift and thrust, combating aerodynamic resistance, reducing rotor-airframe aerodynamic interactions, maintaining helicopter stability, and lowering fuel expenditure. In this article, the internationally recognized teacher and researcher, Dr. Simon Newman, takes us on an exciting journey of 70 years of research, design, and development which has produced a delightful variety of rotorcraft configurations. The author shows how the combination of deep aerodynamic knowledge and innovative designs successfully minimised, and in some cases eradicated, some inherently adverse effects to create highly capable and versatile helicopters.

As a historical background, the author discusses the aerodynamic difficulties associated with the helicopter rotor. The rotor blades are inefficient in forward flight because they operate in an edgewise sense, in contrast to operation as a propeller in which the blades spin about their axis of rotation. Clearly, this places a limit on the maximum obtainable speed. Another restraining factor was the so-called “aerodynamic stall” occurring over rotor blade tip regions when the forward speed increases. The consequence of this is an abrupt reduction in blade lift at high speeds. Furthermore, the important issue of controlling a helicopter in flight is highlighted showing how it is closely related to the design of helicopter’s rotor. In forward flight for instance, the advancing blades generate a higher lift compared with the retreating side, resulting in a destabilising rolling moment. In terms of power requirements, the relatively low power consumed in hover increases rather rapidly in forward flight in order to overcome the aerodynamic drag: the parasitic fuselage drag and the profile (shape dependent) drag from the rotor blades.

The aspiration for ever higher cruising speeds was the chief driver for the wide range of helicopter designs. In the process, it was important to realise that not only the configuration is important but equally the way in which the aircraft is flown. Starting with the traditional single main and tail rotor invention, the main rotor provided all lift and thrust but induced a destabilising torque which was counteracted by the tail rotor. Despite its effectiveness in hover, this simple and elegant design was unfortunately power hungry due to the additional power required to operate the tail rotor. In a logical step to shift the required power to drive the tail rotor to increase the lift and thrust of the main rotor, some designs soon emerged that disposed of the need for a tail rotor while maintaining stability and control. For instance, the tandem rotor configuration was introduced where each rotor cancels out the rotating torque of the other, while achieving yaw control. Inevitably, this allows all the engine power to be devoted for lift and thrust thus increasing the maximum level flight speed. Another appealing design was the coaxial rotors which created a more compact helicopter capable of using all available engine power for lifting payloads. In addition to

ensuring good stability, this compact design is ideal for use in confined spaces such as ship decks. A further fascinating configuration was the tilt rotor aircraft which uses tilting rotors to provide maximum lift in hover, then operates as a propeller in forward flight reaching higher speeds. Other genius designs are also reported including the side by side geometry for use in military operations, the compact synchropter suitable for logging and ship to ship transfer, and the compound configuration concept.

Whilst some helicopters can carry out diverse tasks, there has been no rotorcraft design that can provide solutions to all the problems. This is, however, not a criticism for rotorcraft since the same is true for any transport vehicle. On the contrary, it is a fascinating reality that will offer engineers some food for thought. Despite helicopters being restricted on speed and range compared with fixed wing aircraft, it is evident they will always continue to offer a niche market in addition to their VTOL capability. Militarily, the quest for efficient helicopters is likely to intensify when we consider the drive for military superiority in the 21st century.

High Speed Trains in Algeria

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The article entitled ‘High speed train characteristics and prospects for high speed railways in Algeria’ review the history of different mass transportation, focusing on trains and their increasing speed.

After an introduction to the most famous high speed trains in Europe and in Asia (mainly Japan) and their peak speeds, data showing the growing use and developments in the world are presented.
Operating as such high speeds, trains must display a number of characteristics for economical, safety, and environmental impacts. They are:

- shape which must be aerodynamic in order to travel at fast pace and use less fuel. It is also important for overcoming side winds reduce shear stress.
- use of light materials: again, to travel faster, lighter but stronger materials are being introduced and used more and more in high speed trains.
- different Track’ structure has to be build to run fast trains as old conventional tracks are not suitable. This include canted or banked tracks to overcome curved tracks.
- Cost: This is always the most important factor, including building, maintenance, security and factors specific to each country.
- Environmental impact: Trains have always been regarded as environmental friendly compared to other mean of transport. It could be argued that due to high energy consumption is not very friendly.

After a detailed description of all factors to be considered for the construction of a high speed train, the article looked at the possibility for such a train in Algeria. With its own specific problems, Algeria is different from other African countries. Even other North African countries have different problems. The existent rail tracks are very obsolete and suffer from many of the developing countries ‘diseases’. They lack punctuality, reliability, frequency and safety. After a tiny development and revival in the 1980’s, it went back into obscurity in the 1990’s. In that time, air transportation took over, due to road insecurity. When prices became inaccessible to the average Algerian citizen, road transport- coaches, taxis and private cars were extensively used instead.

The article considered the use of high speed trains for passengers? transportation. High speed trains are a better alternative to air transportation which is suffering from long delays, high prices, and the monopole for the medium to long distances. It could create jobs and opportunities as travelling will not be a problem anymore. It could also increase tourism and connections between various Algerian regions and other North African countries which are themselves already building one such system or considering it. It could re-connect regions of Algeria which have been isolated due to lack of transport and other facors. High speed trains could be a successful story if factors are considered carefully. They are:

- Use of competition between international firms especially in this economical crisis.
- Use of international knowledge and

experience in high speed train? construction and the choice for the appropriate technology for Algeria

- A careful study of the Algerian market.
- Total cost including manufacturing, maintenance and running costs.

Despite the fact that Algeria, better than any other African country, due to it oil and gas revenue, can achieve such a grandiose project, it is nonetheless a challenge. Only 5% of its actual track is electrified. The lack of technological knowledge in train manufacturing and maintenance could be a hindrance if not thought carefully and including in a contract.

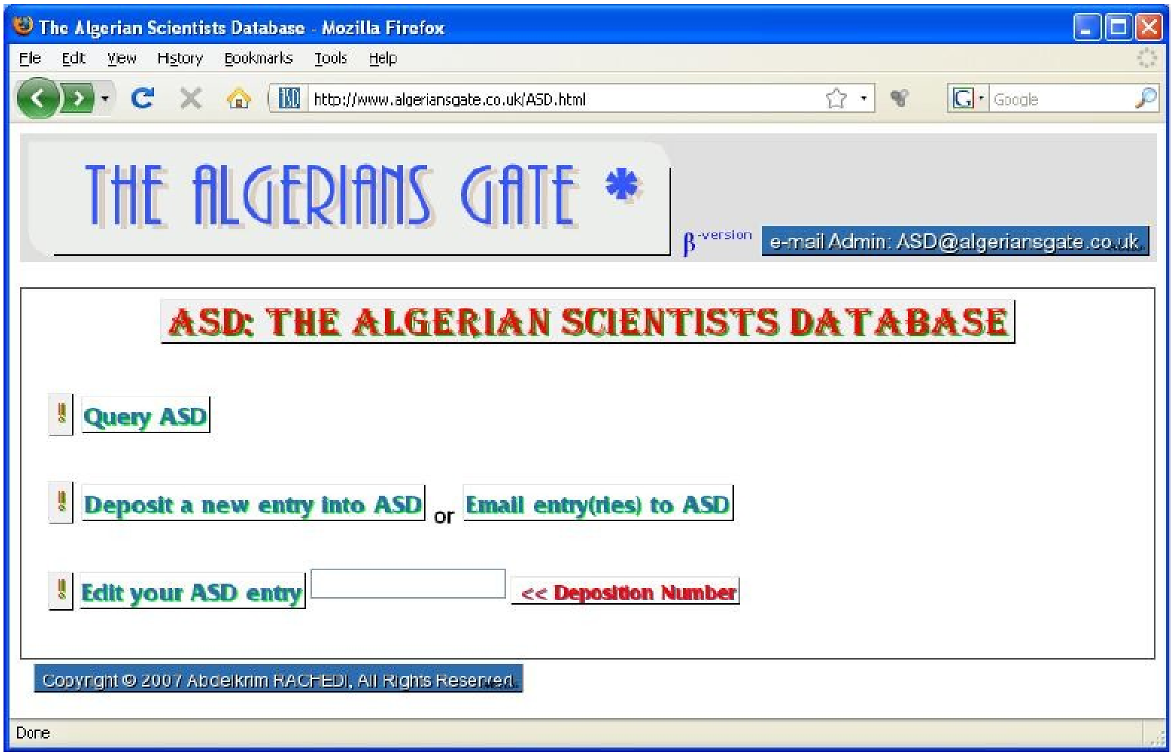
If passengers' transportation s not possible, the article presented the use of high speed trains for freight. Examples of use of HST in Europe for freight have been mentioned and how they could be a greener alternative to air transportation with an ever increasing demand.

One option proposed as an alternative to costly and perhaps lengthy HST construction would be to upgrade the actual system by the use of the tilting technology which enable trains to runs at an acceptable speed, up to 125 km/h and take curved tracks without danger to the passengers as in Spain and in UK.

The main challenges for such a project, as mentioned in the article, are:

- Availability of financial support, knowing that it will take many years to achieve and more funds for ongoing maintenance and repairs.
- National and regional insecurity and safety of passengers.
- Price affordability to an average person.
- Competition from other mode of transports.
- Environmental impact

If all these or even some of the mentioned challenges are overcome, Algeria could be soon enjoying a modern transportation system which will be extensively used. It will increase regional exchanges and development as well and tourism. Algeria is in need for such a system but one should be careful to build an appropriate system, not too costly or too modern which will take to long to build and to expensive to run.



The Algerian Scientists Database (ASD) is an online database that provide users with a tool for worldwide searching and tracking Algerian contribution to science and the scientists behind the endeavors. In addition, this web resource provides users, should they elect to, with the abilities to deposit new entries and edit them when needed.

The ASD is accessed at http://www.algeriansgate.co.uk/ASD.html. Three main features characterize this service:

1. Simple and Easy querying/searching of the database by scientist names or field of work.
2. Data integration is a quality feature to this database, which means that, whenever is possible, data displayed in the entries would contain URL links to other known public databases or sites in relation to the entries.
3. Interactivity is another quality feature of the ASD and is provided through the deposit tool that enable willing users to **submit new entries** for scientists that are not currently in the database and through the editing tool that allows for changing, updating or adding to previously user deposited entries.

In addition, the e-mail address ASD@algeriansgate.co.uk is provided to users to e-mail for inquiries and/or suggestions.

Querying the database can be started by clicking on the button entitled as 'Query ASD'. Theinterface allows users to search the ASD by either Author names (First or Last names) or by Field of work of the scientist. In addition, this interface allows users to display the current list of scientific fields that are found in the database (button entitled 'ASD Fields').

Clicking on a name from the list of results displays a summary list of the authors scientific and/or academic work. Further clicking on any link in the list will display a page describing details of the entry in.

Users can voluntarily deposit new entries into the ASD database. This can be in two ways; Form Deposition and Email Deposition as clearly labeled in the interface.

ASD also provide possibility to edit entries by those users who happened to have voluntarily deposited entries into the ADS database or by scientists whom ASD have entries for and who requested to enjoy such a privilege. In both cases, users will receive a per entry Deposition Number that can used to edit or update entries.

The ASD database aims at exposing the scientific contribution of the Algerian scientists to the world, and would help the scientists worldwide to know each others work and encourage them to collaborate and share knowledge.

The ASD would also help the Algerian officials such the Ministry of Higher Education & Scientific Research to harness the potential of Algerian scientists, especially those working abroad, from wherever they are based, thereby minimizing the effect of the brain drain phenomena that Algeria suffers from for a long time now.

Articles

The Intricacies of Rotorcraft Design

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Introduction

In the autumn of 1986 a helicopter sped across the Somerset Levels achieving a world speed record for its class. This was the culmination of years of research, development and practical application and which resulted in a revolutionary rotor blade design. This enabled a Westland Lynx to overcome the aerodynamic limitations which plague the helicopter main rotor. To emphasise this, the speed achieved was 216 knots which was 63 years after a fixed wing aircraft achieved the same speed. So what is the problem – why should the helicopter have such a problem in achieving high speed flight?

Figure 1: Westland Lynx (Agusta Westland)

Over the years following the Wright Brothers' flight from Kill Devils Hill and Samuel Franklin Cody's achievements 100 years ago at Farnborough, a dream of aeronautical engineers has been the ability to take-off and land vertically and to be able to fly at a considerable speed. The former is possible in several ways from rotor to propeller to fan and then to jet thrust. However, because of its vertical take-off and landing capabilities, the helicopter is a different type of aircraft and in order to compete with a conventional aircraft it needs to be able to hover and, in addition, to convert into and out of forward flight. These place different requirements on the aircraft design and to be able to attain both together generate unique challenges for the helicopter designer. It must be able to operate in these flight regimes economically which is particularly appropriate in the world today where lowering fuel consumption requires the designers to constantly monitor the power requirements.

Efficiency in the hover can be examined using relatively simple theories which show that a large diameter rotor is the most efficient solution. As helicopters spend a proportion of their flight time at low speed, or in the hover, conventional designs tend to have a large diameter rotor. The power required in the hover is considerable and of the various contributions, the majority is required by the generation of the thrust force. This, so called, induced power forms about 70% of the total required to hover.

As well as attaining an efficient hover, the helicopter must now be analysed as it moves into forward flight. The power components change considerably as the rotor(s) experience the effects of forward flight speed. The induced power, which dominates in the hover, reduces significantly as the forward speed provides a ram effect. Conversely, the power consumption required to overcome the parasitic fuselage drag force, which is equal to zero in the hover, now becomes the dominating factor at higher speeds. The power necessary to overcome the aerodynamic drag of the rotor blades themselves (profile power) increases more modestly. The rate of increase of the profile power, with forward speed, remains modest providing the blades do not experience stall. However, this increase will be much greater if the rotor penetrates the stall boundary. An examination of the power component variation with forward speed shows that a significant dip in the total power occurs at a speed of around 70 knots after which it increases to a value similar to the hover at its maximum speed. This characteristic power variation significantly influences the manner in which the helicopter is flown.

It has been a continuing aspiration to design a helicopter to fly at higher forward speeds. Unfortunately, in addition to overcoming any power limitations, the rotor(s) themselves suffer from aerodynamic limits which have prevented the conventional helicopter from achieving high speed forward flight. The ability to hover efficiently and to fly at high forward speed is not economically achievable. The search for the combination of vertical take off and high forward speed in a single air vehicle has a long history. A large rotor diameter, as used in the helicopter is not entirely appropriate for forward flight as a propeller. The idealised blade geometry differs significantly between them. For this reason there have been many different rotorcraft configurations devised, built and flown. These will be discussed later, but first the aerodynamic difficulties of a helicopter rotor need to be examined.

The Rotor Problem

The rotor is mounted on the fuselage with the shaft essentially vertical. This is ideal for the helicopter in hover to support the weight, but as the aircraft commences forward flight, the rotor moves in an essentially edgewise sense. This is fundamentally different to a conventional propeller which moves along its axis of symmetry. In addition, the main rotor is the only means, in a conventional helicopter configuration, of providing the forward force component to overcome the drag and hence sustain forward flight.

There may be circumstances in which a large main rotor size may not be feasible. In such circumstances the helicopter will not be able to hover with same efficiency. This is appropriate for later versions of rotary wing aircraft where they can convert from helicopter mode to fixed-wing mode such as the BA609 tilt rotor aircraft. Therein lays the conflict. The layout of the main rotor, or main rotors, and possible tail rotor gives rise to the many different types of rotorcraft configurations that are seen today and of the future.

The advancing side is where the rotor blade is moving in the same direction as the helicopter – relative to the air. The retreating side is where they are moving in opposite directions.

This edgewise motion of the main rotor combined with the forward speed produces a difference of aerodynamic conditions between both sides of the rotor. Because of the relative motion directions of the rotor blades and the fuselage, the rotor naturally divides into two halves, separated by the longitudinal diameter. These two divisions are termed the advancing or retreating sides. (The advancing side is where the rotor blade is moving in the same direction as the helicopter – relative to the air. The retreating side is where they are moving in opposite directions.)
This applies to the original rotary wing vehicle – the autogyro – and one of the pioneers was the Spaniard, Juan de la Cierva. In his original career, he was familiar with the use of trusses to isolate mechanical components from transmitting moments between each other. This knowledge enabled him to devise the solution to the problem that if nothing else was changed on the main rotor the dissymmetry of lift would cause a roll moment to develop which would ultimately cause aircraft to roll over out of control. He used his experience and came up with the concept of

using hinges which enable the rotor blades to move in a vertical sense out of the plane of rotation, known as flapping. The inclusion of flapping hinges isolates the hub from the rotor blades – and inconsequence – the blades from the hub. This has two consequences; firstly the blade position in the flapwise sense is governed by the balance between the aerodynamic lift, increasing the flapping angle, and the centrifugal force, decreasing it. The difference in the flow velocity between the advancing and retreating sides of the rotor disc (the plane traced out by the blade tips), causes the rotor to flap up at the front and down at the rear. As the rotor thrust vector is normally considered to be perpendicular to the rotor disc, the rearward disc tilt will create a rearward component of thrust which will decelerate the aircraft. In fact, in order to avoid the rolling moment, the inclusion of flapping hinges, in isolation, will prevent the helicopter from achieving sustained forward motion. The tendency for the rotor disc to tilt rearwards has to be reversed which will then permit the thrust to have a forward component which will overcome the drag force and sustain the forward motion.

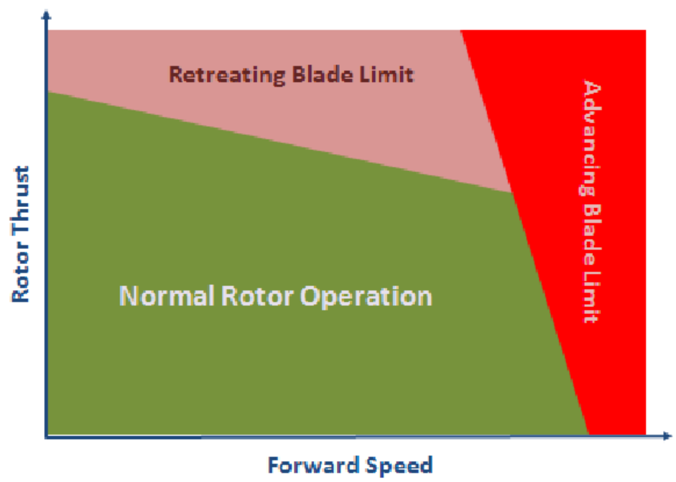

Figure 2: Rotor Limits

We therefore have the situation where as the helicopter attains forward flight, control of the rotor must be provided and the generation of forward propulsion requires that each rotor blade must be subjected to a once per revolution variation in pitch angle. This overcomes the effect of the velocity over the blades (advancing/retreating sides) and forces the blades to flap up at the rear of disc and down at the front. This blade pitch variation, at a frequency of once per revolution, is known as cyclic pitch. This brings in the second effect of the provision of flapping hinges which is a distinct disadvantage. As the forward flight speed increases so the thrust potential of the main rotor decreases. Maximum lift can be generated with a high dynamic pressure over the blades coupled with a high pitch angle. The situation of the advancing side and retreating sides of the rotor is directly opposite to that situation giving a thrust limitation with increasing forward flight speed. The retreating side tends to give the majority of the difficulties as the rotor blade speed through the air is reduced and extra pitch is required to balance the rotor in roll. Even though the advancing side has an increased speed of airflow over the blades, it tends to have a problem at the very highest forward speeds where the Mach number over the blade tip regions puts a severe limitation on the aerodynamic lift of the rotor and therefore it tends to appear as an abrupt limit to the forward flight speed. These limits are shown diagrammatically in Figure 2.

Aerodynamic design has improved the performance of a helicopter rotor enabling higher speeds to be obtained - as personified by the World Speed Record Lynx. However, to attain a flight speed comparable with fixed wing competitors, a complete change in the aircraft configuration and manner of flight is necessary, which has resulted in a wide range of aircraft designs.

Single Main and Tail Rotor Configuration

This particular configuration is the most common type and the main rotor provides control in five of the six axes, namely the three translations plus roll and pitch. To cater for the final degree of freedom of yaw, a rotor is placed on a boom at the tail end of the aircraft, rotating in a vertical plane. The thrust is varied by the pilots yaw controls (foot pedals) which gives a variation in torque about the main rotor shaft axis. This overcomes the torque reaction of the main rotor drive and also permits changes in aircraft yaw position.

This configuration is characterised by a large main rotor which makes it efficient in the hover and has a very extensive range of uses. As the main rotor provides the support for the aircraft, trimming in pitch is very sensitive to the mass distribution over the complete aircraft which results in a very small longitudinal centre of gravity range. A good example of this type of aircraft is the EH101 - Merlin which is shown in Figure 3.

Figure 3: EH101 Merlin (Agusta Westland)

Tandem Configuration

The tandem configuration has a main rotor placed at each end of the fuselage rotating in opposite directions. This enables yaw control to be achieved without the provision of a tail rotor. Since the aircraft is supported by the main rotors longitudinally placed at each end of the fuselage, the centre of gravity range in the longitudinal direction, for this configuration, is very large with longitudinal trim being achieved with differential rotor thrust. In forward flight the rear rotor has the potential problem of flying in the aerodynamic wake of the front rotor. To minimise this effect, the rear rotor is located at the top of a pylon which raises the disc plane above that of the front main rotor. This can be seen in Figure 4. For level flight this works very effectively, however, when the aircraft is coming into land, in order to decelerate, the rotor thrusts need to tilt rearwards and the fuselage adopts a nose up attitude. This pitch rotation causes the rear rotor to move downwards which positions it in line with the downwash from the front rotor. This change in relative position results in the rear rotor working in effectively a downdraught. There is now a danger of the rear of the aircraft sinking further. This is a particular problem when flying close to ground especially when coming into land.

Figure 4: CH46 (US Navy))

Placing the main rotor on the rear pylon raises the rear rotor disc plane above that of the front rotor. This creates the generation of forces and moments which couple the various degrees of freedom. For instance, if the helicopter executes a circular turn the front and rear rotors are tilted in opposite senses to create the yawing moment required to turn the fuselage in yaw. The rotor thrust forces are usually taken to be normal to the rotor discs which means they are inclined to the vertical in opposite directions. As the rear rotor is placed above the plane of the front rotor, these inclined thrust forces will form a couple both in yaw and roll and the aircraft will therefore tend to roll in addition to yaw. If the aircraft is flying forwards, then the rolling direction is in the opposite sense to what is normally considered a coordinated turn (i.e. rolling INTO the turn). An adverse coupling can also be generated if the centre of gravity is not placed at the mid point between the rotors. The position of the centre of gravity will make one rotor have a thrust in excess of the other rotor to maintain pitch trim. In the situation of the aircraft flying sideways the different thrust values, when tilted sideways will create a yaw coupling which will cause the aircraft to turn and a pure sideways motion is prevented. Whilst there are potential difficulties, the tandem configuration is an extremely valuable transport type of helicopter and a good example is the Boeing Vertol CH-46 shown in Figure 4.

Side By Side Configuration

In contrast to the tandem configuration, where the rotors are placed longitudinally, the two main rotors in the side-by-side configuration are located laterally on either side of the fuselage. As in the tandem, the rotors rotate in opposite senses giving the required yaw control. In forward flight, both rotors experience the same incoming airflow and therefore the problems of rotor interference seen with a tandem helicopter do not apply to the side

by side configuration. The centre of gravity range with the side by side configuration is in a lateral sense. As the fuselage is in a longitudinal sense, this at first sight seems somewhat superfluous.

Figure 5: Mil 12 (Erik Frikke)

However it does afford such an aircraft the ability to fire weapons, which would normally be positioned laterally along the structure supporting the rotors, and roll trim can be maintained by adjusting the main rotor thrusts. The positioning of the main rotors also allows the fuselage extremities -the nose and tail sections - to protrude from outside of the periphery of the rotor disc planes. With the nose section of the fuselage protruding forward of the main rotor discs there is now the potential for crew ejection, in a vertical direction, whilst avoiding the rotors. Also with the tail section protruding rearwards from the two main rotor discs allows a weapon sight to be fitted to a gantry which can extend upwards and remain clear of the rotors. Hence, an observation platform can be placed above the plane of the rotors without the need for communication paths to be located within the rotor shaft which is what is normally seen with the single main rotor configurations. A good example of this configuration is the Mil 12 as shown in Figure 5. The layout of the rotors requires an extensive supporting structure. This, of course, will add a significant amount to the drag of the aircraft.

Coaxial Configuration

With the rotors placed at extreme positions the tandem and side by side configurations occupy a considerable volume. This is does not present an immediate difficulty when considering land based operations (operations close to trees excepted), however, with shipborne operation storage volume is at a premium. The coaxial configuration has both rotors placed on the same axis of rotation, rotating in opposite directions.

Figure 6: Kamov Ka32 (Luis Rosa)

Roll and pitch control is achieved by tilting both rotor together whilst yaw control is achieved by differential torques on the rotors. With one rotor being placed below the other, the downwash from the upper rotor must pass through the lower rotor. This will have ramifications for hover performance - as a rule of thumb, coaxial helicopter performance in the hover is often considered to be equivalent to that of a single main rotor helicopter supplying the total thrust required with the coaxial rotor radius.

operations close to trees excepted

This will increase the hover power as the rotors are usually smaller in diameter. As the coaxial configuration operates very much as a single rotor helicopter, the centre of gravity range is also very limited. With the two rotors rotating in opposite senses there is no need for a tail rotor to provide yaw control. This gives a very compact configuration which makes it suitable for shipborne operation. This is well shown with the Kamov type of aircraft, an example which is shown in Figure 6.

Synchropter

The coaxial helicopter has rotors placed on the same rotational axis. However, two rotors can be incorporated on separate shafts by correct inclination of them relative to the fuselage. Each rotor has its own shaft which is inclined outwards and, by correct rotational phasing of the rotors, any clashing between the two rotors is avoided. The synchropter variant was founded by the pioneer Anton Flettner and is normally associated with the Kaman helicopter company. Their Huskie and K_{MAX} aircraft are good examples of these consisting of two rotors with two blades. The controls for each rotor can be separate as there are now two rotor shafts, unlike the coaxial configuration however, the advantage of a compact layout and yaw control are still retained. This compactness makes it particularly suitable for use in confined areas such as logging and ship to ship transfer. This has given the

K_{MAX} a niche market and is often advertised as an aerial truck and an example is shown in Figure 7. Kaman aircraft have a particular type of control system.

Figure 7: Kaman K_{MAX} (Stewart Penney)

Most manufacturers achieve rotor control using a system operating on the rotor blades themselves by altering the blade pitch at the root end by mechanical linkages. With the Kaman type of aircraft, the blade pitch change is achieved through the elastic twisting of the rotor blade achieved by the aerodynamic pitching moment generated by a trailing edge flap positioned approximately two-thirds of the way down the rotor blade itself. This can be seen in Figure 7.

Convertible Rotor

To obtain higher flight speeds but still be able to take off and land vertically, new configurations have been developed over the years in order to overcome the limitations caused by the rotor aerodynamics. One solution is achievable by rotating the rotor shafts in pitch by which means the supporting force in hover can be transferred to forward propulsion in conventional forward flight. As the aircraft attains fully developed forward flight, the rotors are aligned axially and the advancing/retreating blade problem is now avoided. This type of solution has spawned two particular variants, namely the Tilt-Rotor or the Tilt-Wing. Amongst present day aircraft designs, the tilt rotor is typified by the BA609 aircraft, which is shown in Figure 8.

Figure 8: Agusta Bell BA609

In the hover it operates in a similar mode to a side by side configuration helicopter; however, the two rotors are able to rotate with their nacelles about a horizontal axis and, after fully rotating, point forwards. The aircraft is now transformed into a twin propeller-driven fixed-wing aircraft. Because the rotors have to rotate about the horizontal axis, the rotor radius is limited in size to avoid interference with the fuselage. The reduced rotor size will raise the hovering power. Since the rotors now have to operate in the roles of a supporting rotor for VTOL (or helicopter mode) and a propeller in forward flight mode, the geometry of the rotor blades must now be a compromise. Conventional propeller blades are highly twisted so as to align the blade sections correctly with the forward motion which is in an axial sense. This is usually of the order of 60° to 90°. Conversely, a helicopter rotor blade usually has a twist in the region of 8° to 10°. A convertible rotor blade twist will lie somewhere between them, say 50°.

Compound Helicopter

As outlined in the introduction, an edgewise main rotor, which supplies both support and drive for the helicopter, forms one of the main limitations of helicopters which is the forward flight speed trap. As the problem is rooted in the main rotor having to supply the lift and propulsion, one way past the speed trap is to divorce the requirements of having to support the weight of the helicopter and to provide the forward propulsive force. This is the concept behind the compound helicopter configuration. It achieves this solution by providing a fuselage with wings to offload the rotor together with an auxiliary propulsion device. A particularly good example of this type of configuration is the Lockheed Cheyenne helicopter of the late 1960's and early 1970's, which is shown in Figure 9.

Figure 9: Lockheed Cheyenne (Lockheed)

This aircraft took the concept of a single main and tail rotor configuration to which was added stub wings and a pusher propeller at the rear of the tail boom synchronising with the tail rotor. With this layout both the vertical and horizontal force balance of the aircraft could be adjusted independently of each other using the main rotor and pusher propeller blade pitch respectively. This particular aircraft achieved great speed but, as with all winged rotorcraft, suffered in the hover. The stub wings are correctly aligned in forward flight but as the helicopter translates to the hover they now become effectively at 90? incidence. The rotor downwash will now generate a large downforce on the fuselage structure which in consequence requires the helicopter rotor to generate a still higher thrust level. (*This is technically known as rotor blockage.*) All main rotors suffer from a degree of blockage with the fuselage interrupting the downwash but wings accentuate this effect.

The provision of stub wings made the Cheyenne an aerodynamically efficient weapons platform and the provision of the pusher propeller gave the pilot close longitudinal control of the aircraft. This was achieved by providing a driving force to the helicopter for the high-speed operation and to behave as an airbrake if the aircraft is in a dive.

A totally different type of aircraft developed as a compound is the Rotodyne - see Figure 10 - and was designed by Fairey Aircraft in the 1950s. The essential difference with this design is that it used a tip drive for the main rotor. Forward propulsion was provided by a pair of airscrews. The airscrews were installed directly on to engines placed in nacelles on short wings projecting from the fuselage. Pressurised air was taken from the engine and transferred via ducts in the rotor hub and blades. This was then turned through a right angle and ejected rearwards providing the power to drive the rotor. The air bleed was taken from the compressors of the Napier Eland gas turbine engines and fed through the system of valves and seals along the rotor blades to the tip jets. Each engine fed a pair of opposing rotor blades giving a balanced torque in case of an engine failure. An essential difficulty of this type of reaction rotor propulsion is that the tip of each blade is moving fast relative to the air. The jet efflux needs a high velocity in order to develop the necessary propulsive thrust by overcoming the rotational velocity of the blade tips. With the Rotodyne rotor design, the pressurised air was not sufficient and so the pressure air thrust was augmented by feeding fuel along the rotor blades to the tips and burning it essentially as an afterburner. This had the distinct disadvantage of creating a considerable amount of noise which proved a very difficult problem for the eventual marketing of the aircraft.

This regime allowed the aircraft to take off and land vertically and operate in flight close to the hover. In forward flight, the airscrews provide the propulsion whilst the pressurised air from the engines was progressively shut down. The main rotor was allowed to tilt rearwards and operate like an autogyro deriving rotor power from the upward flow component of forward speed caus-

ing the rotor to autorotate. The wings supplied a proportion of the lift in forward flight and a full empennage gave the Rotodyne its weathercock stability. Differential airscrew thrust was used to give yaw control in and around the hover.
Technically it still achieved forward flight speeds which are still impressive for rotorcraft of today.

Figure 10: Fairey Rotodyne (Agusta Westland)

Final Remarks

This paper has provided a brief survey of the various types of rotorcraft which have appeared in the past 70 years. The range can be seen to be many and varied.
The helicopter supplies a niche and will therefore appear in a variety of guises, each designed to a particular requirement and to fulfil a particular purpose.
The ability to take off and land vertically under full control, coupled with an ability to transfer to and from substantial forward flight speed is a considerable proposition.
VTOL has unique benefits but it has to pay a considerable price.
The continuing search for high speed has fuelled the many number of research projects seen over the years.
Amongst the many decisions that need to be addressed are:

How to drive the rotor system?
In the majority of rotorcraft designs; this uses internal engines which, in order to possess the required yaw control, a tail rotor device or a multi-main rotor layout is used. The transmission system provides mechanical support for the aircraft and so operates under considerable flight loads in addition to accepting the engine torque, modifying the rotational speeds and splitting the drive between the various rotors. It is a vital component and much effort is devoted to its design and installation in the airframe.

The rotors can also be driven externally via tip propulsion. With this regime no additional controlling torque is necessary for the yaw control of the aircraft fuselage. In addition, this now removes the need for the extra tail rotor transmission. This type of propulsion has been developed in the past and, with recent aircraft projects, is being examined for the future - this type of rotorcraft still has its potential. Since the propulsive drive is via jets with small diameters, the efficiency will not be as high as a conventional rotor system with the attendant higher usage of fuel. The question is how to spend your money; the choice is either an internal drive system which is more efficient but carries the weight penalty of a transmission or a tip drive propulsion system which less efficient but the reduced weight has the ability to carry the extra fuel required. Introduce the potentially higher flight speed and the decision becomes particularly profound.
The arrangement of the rotors is the final decision. There is no immediate answer as the operational requirements of the design have a total influence on the airframe configuration. The many different layouts of the rotors illustrate the many different operations the rotorcraft has been asked to fulfil.

As a final comment, the question can be asked as to whether a helicopter configuration could replace a transcontinental type of fixed wing aircraft. It would benefit from the VTOL capability, but the speed and range would be, almost certainly, inferior. CTOL is still the choice since it has the long range capability.
Rotorcraft cannot solve all of the many problems, however, their efficiency in and around the hover, together with the effectiveness afforded by the VTOL capability will ensure that they will always have a contribution to make in the future of aeronautics.

Articles

High Speed Train Characteristics and Prospects for High Speed Railways in Algeria

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Introduction

Trains represent one of the oldest powered modes of transport, with rail travel booming in Europe in the 19th century as a result of the industrial revolution. Like other transport systems, train development has undergone an evolutionary, rather than a revolutionary, process. It is reported that even as early as 1939, some trains recorded top speeds of about 165 km/hr [6] which was pretty fast. However, it was only from the 1960's, specifically in Japan, that the notion of high speed trains was fast emerging. The speed-up in train transportation was dictated by parallel developments in air and road transport, all driven by a timely requirement for the mass transportation of passengers and goods. For instance, the Concorde was introduced as a Supersonic air transport, while Japan introduced the Shinkanssen high speed train series in 1964 to cope with the increasing demand for mass travel between its highly condensed and close together cities. These trains achieved top speeds in the region of 210 km/hour [6]. Other notable high speed train programmes were subsequently developed in France who introduced the TGV and in Germany with its ICE tilting train concept. Figure 1 shows snapshots of these three trains.

(a) Japanese Shinkansen (b) French TGV (c) German ICE

Figure 1: Examples of modern high speed trains [8]

The current world speed record of a high speed conventional train (i.e. excluding Maglev trains) was achieved in 2007 by the French TGV which managed to run at 574.8 km/hour on a test route [6], although in practice the operational speed is lower in the region of 350 km/hour. Current Shinkansen trains run in excess of 300 km/hour while the ICE also runs at a maximum speed of 300 km/hour.

High speed railways are now prevalent in Europe with many high speed lines connecting different countries. For instance, there is the well known Eurostar fast train service linking the capital cities of the UK, France, and Belgium. The European Union (EU) currently controls 70% of the world?s passenger and freight rail market with a total turnover of 36 billion Euros [2]. In addition to Japan, other Asian countries like China and Korea are fast becoming strong competitors in the high speed rail business. Also in South America, notably Brazil and Argentina, ambitious plans for high speed train travel have already been unveiled. The volume of global high speed rail travel continues to grow as shown in Figure 2.

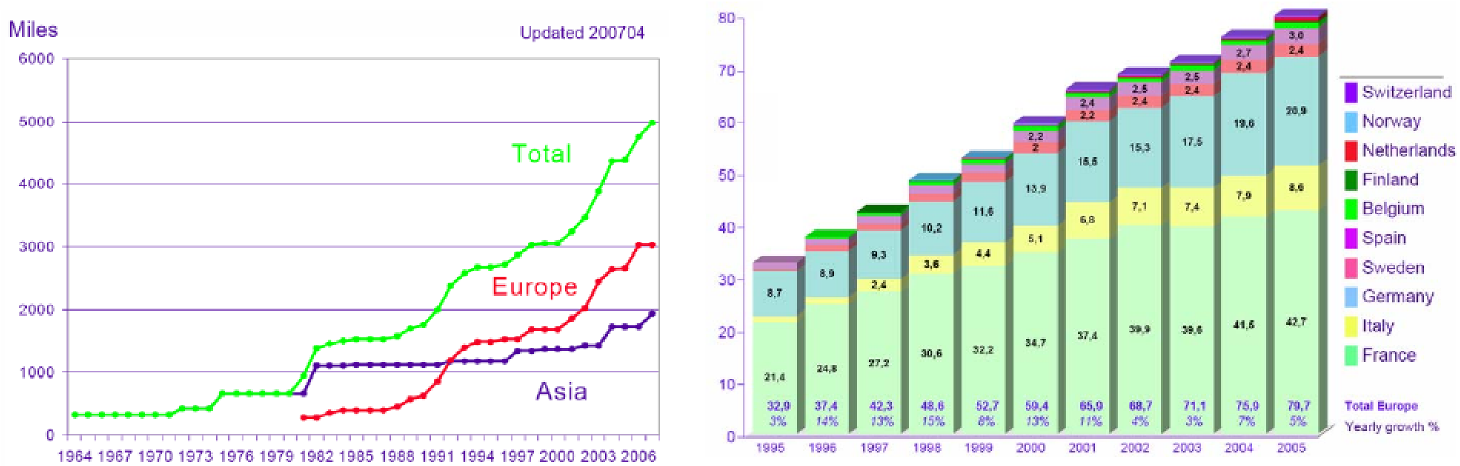

Figure 2: High speed train travel will continue to grow [1]

The technological advances which have been incorporated in high speed trains have led to a characterisation of high speed rail travel in many ways. The specific issues that must be considered when operating at high speeds are explained in the following section.

Characteristics of high speed railways

1- High speed aerodynamic features

Unlike conventional rolling stock which has bulky bluff body shapes, high speed trains are streamlined, long and slender. The streamlining effect is necessary in order to reduce the air resistance, or drag, to train motion. The drag force varies with the square of train velocity, implying disproportionately larger fuel consumption at higher driving speeds. The slender shape along with the use of increasingly light weight materials means that high speed trains can be susceptible to strong side winds. The associated unsteady aerodynamic forces can reduce the train?s stability, causing it to overturn. Fortunately, due to operational measures, only a relatively few overturning accidents due to side winds have been recorded since the 1960s. Strong crosswinds are experienced at exposed sites such as embankments and bridges. High speed trains are also designed in a way that allows them to travel inside tunnels to cope with the undesirable flow behaviour inside tunnels (such as compressive/expansion pressure waves which can affect the comfort of passengers and can cause the generation of high levels of aerodynamic noise from tunnel walls). Some of high speed trains are quite long allowing them to transport a large number of passengers, although this is also true for standard trains. For instance, a high speed TGV can transport 3.5 times the number of passengers than an Airbus A320 is able to.

2- Light weight materials

The driving force in the use of light weight materials is the need to maximise the number of passengers and/or minimise the fuel consumption by reducing the cost of heavy materials that require more energy to move. At the same time, these materials must withstand harsh conditions (high temperatures, dynamic loading, etc) and large aerodynamic forces at high speeds. Without compromising safety, light weight materials for high speed trains must have good strength characteristics (crash worthiness characteristics) and also fatigue properties. Composite materials in particular, which provide a combined benefit of reduced weight and increased strength, are increasingly being used by leading train manufacturers like Alstom and Bombardier [7].

3- Track structure and equipment

Compared to older track designs, high speed trains may need upgraded structures. These may include line electrification for non-electric lines. An additional requirement is for the distance between tracks to be increased when compared to conventional lines, in order to reduce the impact of transient forces when two trains pass each other at high speeds. Further, high speed trains impart larger dynamic forces on the track compared with conventional trains, necessitating an improved track bed construction. This may take the form of thicker ballast and sub-ballast layers, or improvements to the strength and stiffness of the foundation of the track bed (i.e. subgrade).

4- High speed operation on curved tracks

In contrast to conventional trains, High Speed Trains (HST) are able go around curves at higher speeds provided an adequate centripetal force is proved. However, the associated centrifugal force acting towards the outside of the track can cause discomfort to passengers. Two main technologies have been built to enable trains to travel fast on curves without discomfort to passengers.

The first is to introduce canted tracks (or banked tracks) in which the outer rail of the track is super elevated (or canted) compared with the inner rail, while the second is to use a tilting train along with a canted track (for example those in the UK, Sweden, Spain, USA, and Germany). Figure 3 is an example of the Swedish X2000 tilting train. Tilting trains may be operated on existing tracks but are limited to certain speeds.

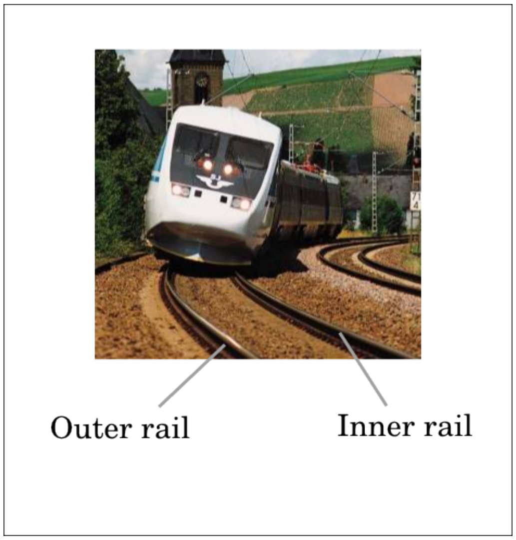

Figure 3: Swedish X2000 tilting train (speed 200 km/hour)

Without upsetting passenger comfort, trains that tilt are capable of achieving between 25-40% more speed when going around curves. Clearly, this reduces the travelling time. For lines dedicated only to high speeds, the trains do not usually have a tilting mechanism because curves are built with high radius to balance the track accelerations. Examples of these include the French TGV, the German ICE and the Japanese bullet trains the Shinkansen series.

5- Cost of high speed railway construction

The cost of building, running, and maintaining a high speed rail network is huge. For example, in the UK, a recent study has indicated that building two high-speed links would cost the country 38 billion Euros. The proposed new 200 km line in Morocco is estimated to cost 1.8 billion Euros [3]. In Iran, the planned high speed link between Tahran and Mashad is projected to cost 6.7 billion Euros. Egypt revealed it will need to spend 1.83 billion Euros for the construction of a 625-mile, 186-mph, high speed railway linking Alexandria on the Mediterranean coast to Aswan [4].

6- Low HST emissions

Train travel contributes only a very small fraction to released gases compared to aviation and road transport. Trains are a low-carbon, environmentally-friendly alternative to polluting cars as seen in Figure 4.

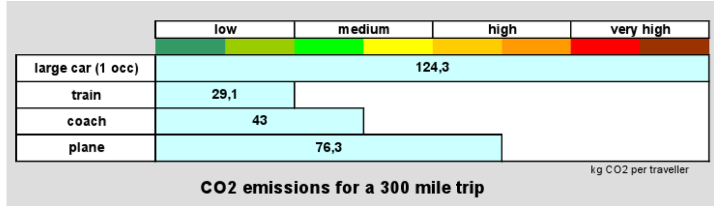

Figure 4: HST contribution to pollution compared with other modes of transport [1]

By close inspection, however, some may disagree that HST does not represent a friendly environment option. The simple argument is that increasing the speed of trains is associated with an increase in the energy consumption. However, with mass transportation on HST lines and roads becoming increasingly congested less people would want to use their cars regularly. This would decrease energy use and thus a reduction in greenhouse gases. The benefits, both in terms of protecting the environment and encouraging economic growth, could only be long-term and so it will be difficult to assess the viability of HST considering the rapid changes in world economy.

Opportunities for high speed trains in Algeria

1- Passenger transportation

There is an increasing volume of passengers travelling via high speed trains whether this is dictated by passengers themselves or via governmental decisions. Not only in Europe but other developing nations have HST aspirations such as Morocco, Egypt, Iran, Saudi Arabia, India, and South Africa. Although Algeria?s railway has a long history due to French influence and the network has expanded after 1980s, there is a need to revive train transportation by investing in HST. The Algerian national rail operator, SNTF, has recently unveiled plans for a number of HST lines. These new lines will connect the major cities of Oran and Annaba (west-east) while passing through the capital Algiers, Setif, and Constantine, reaching the borders of both Morocco and Tunisia. Other cities in the desert region will be connected including Gharda?a, Touggourt, and Hassi Messaoud (oil rich city). It is envisaged that trains will be running at a speed of 250 km/h (155 mph). Other high speed inter city lines are also planned including [6]:

- Algiers - Skikda - Annaba (620 km)
- Algiers- Oran - Tlemcen (770 km)
- Touggourt - Hassi Messaoud (160 km)
- Relizane - Tiaret - Tissemsilt (180 km)

It is expected that work on these lines will begin between 2009 and 2010.

There are many arguments for the potential success of a high speed rail network in Algeria and in North Africa region. At the

moment, the Algerian transport system is strongly unbalanced in favour of a trunk road and motorway network (with the east-west line still not yet completed). A high speed rail network of short and long distance lines can be built to link major cities and towns. One obvious proposal is a west-centre-east line which starts from Oran, goes through Algiers and ends at Annaba. Such a solution could benefit the economy through the associated regeneration of Algerian cities by creating opportunities for employment. The largest proportion of Algeria?s population lives in the north and thus if a good service is provided passenger supply should not be a problem. High speed lines have the potential to satisfy the growing demand for mobility in Algeria. They will also relieve the current congestion on road and in the air. The travelling time is also very important for passengers who currently have to endure long journeys towards the capital Algiers and to their places of work. For instance, it takes more than six hours for a taxi trip between Annaba and Algiers, and more than ten hours by coach. High speed trains with speeds of 200km/hr would reduce this journey to about three hours only. In addition, coach services often lack necessary onboard services especially toilets and air conditioning. Passengers may be prepared to pay for increased travel comfort if it greatly reduces the travel time and offers some basic onboard services.

One other major problem with the Algerian rail is the frequency of services. Despite the SNFT?s control of more than 4,000 km of heavy rail system, this network lacks the intensity of service and frequency of stops needed to solve the problem of expanding cities of populations having to travel further and for longer to their places of work. At the moment, there are only four services each day between Algiers and Oran at 06:30, 07:45, 12:30, and 15:00 [5] although this might be due to economical reasons. If the frequency of service is increased, passengers will have the opportunity to travel at more suitable times and would choose rail due to its flexibility and comfort. This, however, introduces the costing issue for frequent train services.

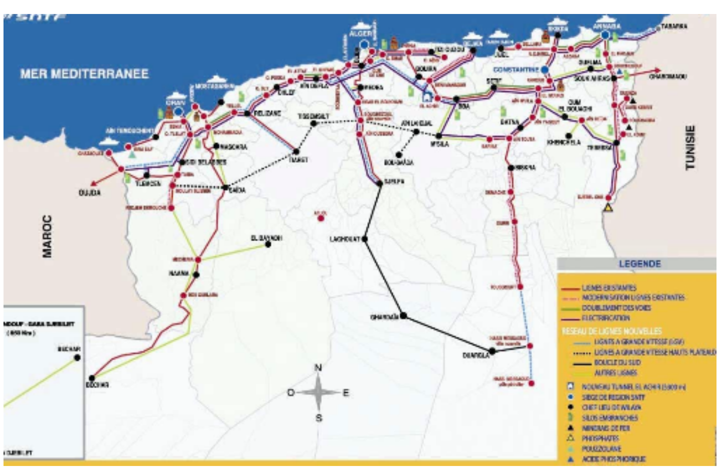

Figure 5: Current Algerian rail network [5]

Most train systems in the world which operate a frequent train service are highly subsidised by the government. In other words, tax payer?s money. The current percentage of train travel in Algeria is far less compared with road travel which is not particularly safe, and suffers from congestion. The current rail network in Algeria is shown in Figure 5.

HST will solve problems of airport delays or cancellations. Air fares are quite expensive thus HST can offer a competitive alternative for high speed capacity trains at lower prices. Compared with air travel where passengers have to undergo bureaucratic hurdles and long waiting times at airports, high speed trains would provide a more effective way of transporting passengers.

In terms of project execution, Algeria can benefit from the fierce competition between European and Japanese firms who are eager to gain new international markets. This means it is possible to negotiate cost effective contracts. Algeria can take advantage of the wealth of experience offered by the European and Japanese train operators and manufacturers. Leaders of high speed rail such as Alstom and Deutsche Bahn continue to provide excellence in manufacturing, with leading edge technology that ensures reliable, safe, and high performance. However, one must remember that manufacturing trains and track is only the start. Whole life costs associated with maintenance are a major consideration.

As already mentioned, building a HST network would generate a large working force, develop national expertise for young engineers, and improve the image of main cities. Contrary to harsh topography of mountainous regions in Japan, China, and the Alpes, Algerian topography is comparatively simpler implying that construction of high speed lines would not be particularly challenging.

It is important to emphasise that HST will only be successful if trains are operated with sufficiently high speed, making them more convenient than air and road travel. In a rapidly expanding Algerian economy people want to spend the minimum time on travelling. In France alone, for journeys of over four hours the high speed TGV takes more than 50% of market share for transport despite being heavily subsidised. Although future travel demand is hard to predict, one cannot argue against the fact that people?s mobility will continue to grow. Algerian?s future high speed rail industry must consider today?s market needs: speed, high flexibility, high profitability, and improved logistics.

One must of course take into account the huge costs of infrastructure: track, control system, building of tunnels, construction of bridges, electrification, and so on. For example, only 238 km of a total of about 4000 km is currently electrified in Algeria. The government must put into place financial plans to sponsor HST even if that means stretching public funding. However, considering the recent rise in gas and oil prices and the subsequent revenues, Algeria should be in an excellent position to start at least parts of its high speed ambitious programme.

Instead of pure competition, HST can cooperate with other

modes of transport particularly air and road. This may be achieved by making train links to airports and coach stations. This would help the objective of promoting the railway contribution to sustainable transport policy in the country, and would improve the competitiveness and economic stability of the railway sector and industry.

2- Use of HST for freight

The use of HST is not limited to transport of passengers but may be used for transporting other goods, or freight. As a practical example, the freight market in Europe continues to grow, thus requiring more transport capacity particularly for parcels and express services. This comes at a time when restrictions on the rapid transport of goods are increasing both in air and on road. In air, airlines have a limited number of flight slots, the screening of goods for security usually takes a long time, in addition to rising kerosene prices. As for roads, quick freight transport is constrained by national speed restrictions on motorways, delays due to road congestion, high charges at some motorway tolls, and rising oil prices. In France for instance, there is a high speed line specifically for postal services and other cargo [2]. It is expected that market share of cargo transport due to high speed rail will reach 25% by 2012 in France [2]. In addition to mail, other freight includes transport of high value goods and express parcels. Compared to road vehicles for express freight, high speed rail freight could offer a green option due to its higher capacity and its use of electric traction.

3- Proposition for a less risky option for HST lines in Algeria

Instead of building a costly and time consuming dedicated HST lines, an alternative option is to upgrade the current network and enable relatively high speeds with changes to train designs through the use of tilting technology. This will enable a HST service to use curves on existing tracks at high speeds whilst maintaining passenger comfort. Two recent major rail projects in Europe that have chosen the tilting approach are good examples. The first project, undertaken by Virgin Rail, who use a fleet of tilting trains purchased from Fiat Ferroviaria in Italy, to run on Great Britain's high-speed West Coast Main Line. The second project is in Spain, where plans are underway for a new line in the Pacific Northwest that will use tilting trains from Patentes Talgo S.A. in Madrid, Spain, to run at comparatively moderate speeds of up to 125 km per hour.

4- Regional HST opportunities in North Africa

Rail links already exist between Algeria, Morocco and Tunisia. Morocco has already announced plans for its HST programme inaugurated in 2007 for a line linking Marrakech to Tangier in the north via Marrakesh to Agadir in the south, and from Casablanca on the Atlantic to Oujda on the Algerian border [6]. It is anticipated that the 1,500 km line will be completed by year 2030. In late 2007, a contract was signed with a consortium led by the French group Alstom to build a high-speed railway between Kenitra and Tangier. With the advent of the HST in Algeria and Morocco, the Maghreb region will become an even more accessible and developed area, creating cross-border sections between the countries, and thus contributing to sustainable development in the Maghreb region. It has been observed recently that an increasing number of Algerian tourists prefer to spend their holidays in neighbouring Tunisia mainly because of a lack of good local services. This occurs despite Algeria having a longer coast line than Tunisia. There are thus real opportunities for regional economic developments and regional competition. The long term goal should be to construct an integrated and efficient HST network which will link the Maghreb countries. Projects of such nature could be facilitated through say, the Maghreb Railway Transport Committee. In terms of train operations, HST usually have similar standards of operations thus linking high speed lines between the countries is possible. It has been proven that in practice even advanced train technologies from elsewhere may be incorporated in a national network, for example use of French technology in Taiwan?s high speed railway system. Algeria and the North Africa region are witnessing a high rate of economic development and there is an urgent need to take advantage of such momentum. HST will help in the region?s aspiration to be a strong economic force in Africa that also links Europe. The proposed link will provide faster transports for tourists who bring a great deal of income to regional economies. This project also comes at a time where governments in the Mediterranean region are pushing for the so called Union for the Mediterranean which aims to strengthen the Euro Mediterranean partnership.

Main Challenges to HST

The main factors that affect HST can be briefly summarised in the following.

- Availability of financial support to sponsor a HST project, knowing it will take a long time to develop and require considerable ongoing costs associated with maintenance. Economic fluctuations may limit funding in the future.
- Security due to national and regional politics
- Affordability for the customers
- Competition from other modes of transport
- Passenger comfort and safety (customer oriented business)
- Lower life cycle costs for the high speed rolling stock
- Easy maintenance and repair
- Environmental impact

Conclusions

Algeria is witnessing an exciting time to expand its current rail network to go in parallel with other international high speed rail projects. Oil revenues should provide some of the necessary funding to build costly high speed lines including electrification, double-tracking, upgrading, and new lines. Population growth and concentration around major cities ensures that passenger numbers will continue to increase. Passengers will be attracted to high speed rail due to safety, comfort, speedy travel, and reasonable costs. With proper management, Algeria can soon be enjoying the benefits of high speed trains. In the long term, the country may need to build dedicated lines for HST travel. It is believed that the current best option is upgrading the existing lines and using tilting train technology to travel at relatively high speeds, hence minimising time and cost.

References

1. Anton van Himbergen, The Sustainability of High Speed Rail Operation. Lloyd?s Register Rail Europe, the 6th World Congress on High speed rail, Amsterdam, 2008.
2. Mathias Emmerich, ?rail high speed cargo in France and in Europe?, the 6th World Congress on High speed rail, Amsterdam, 2008.
3. 'Morocco at the time of high speed train', the 6th World Congress on High speed rail, Amsterdam, 2008.
4. Egypt's plan for high speed rail - Brief Article, Railway Age, August 2000.
5. Website for Algeria's ministry of transport.
6. Wikipedia.
7. Karen Mason, ?Composites Aboard High-Speed Trains?, Composites Technology, December, 2004.
8. Wikimedia.

Book Review

Ten Technologies to Save The Planet

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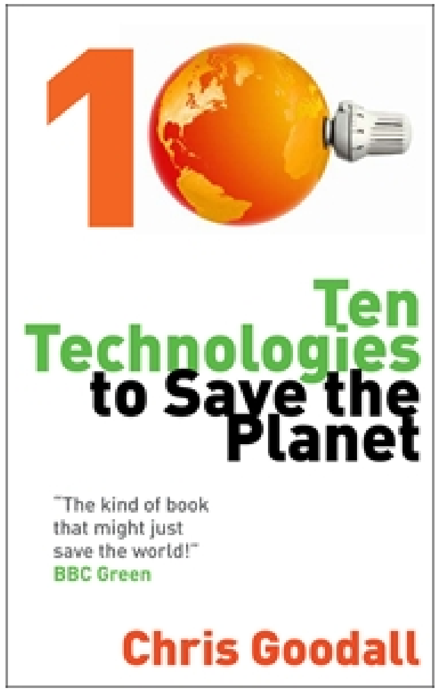
Chris Goodall (2008) Ten Technologies to Save the Planet. London: GreenProfile. ISBN 978-1-84668-868-3.

A friend who has the job of raising public awareness about climate change once told me: As soon as you mention percentages and the centigrade to a typical audience, you have lost them. But there is another school of popular science outreach, a proponent of which is the late Professor Paul Saltman of San Diego. He insisted that (for example) it is not enough for public nutrition campaigns to put food into groups and count dietary portions, but that people need to be taught about metabolism – about the hard science.

Responding to current concerns about climate change and energy security, an optimistic version of this kind of hard science can be found in Ten Technologies to Save the Planet, billed as a popular science book on a hot topic. The author Chris Goodall, not a scientist by training but an alumnus of Harvard Business School, demonstrates herein an often neglected but essential trait in any hard-nosed businessperson: an understanding of basic laws of nature. An entrepreneur, upon encountering a patent document, should be knowledgeable enough to ask (and likely to answer) the question: Does this invention violate the second law of thermodynamics? Goodall's lifelong interest in science, kindled by devoted school teachers, is thus put to good use, distinguishing the specious hype from the scientific advances that can contribute in mitigating or adapting to the effects of climate change.



To enumerate the eponymous items: wind, solar, maritime energies, combined heat and electricity, super-efficient homes, electric cars, cellulosic biofuels, carbon capture and storage, biochar, and agricultural/forest carbon sinks. In the discussions about the first few items, the fact that electricity is a more versatile form of energy than heat or fossil fuels is heavily relied upon. As technologies for the storage electricity improves, a fleet of electric cars can take the central role in a renewable-electricity economy/ecology: doubling as storage devices to soak up electricity when demand is low, and to provide the baseload at other times.

The vision of such an economy/ecology cannot come into existence without large-scale infrastructural investments; for example, a Europe-wide grid that balances out fluctuations among wind, maritime, and solar generation of electricity. For this last source of energy, two main contenders are discussed: photovoltaic and concentrated solar power (CSP). The second one, perhaps lower-tech but better-proven than its companion, is a patently economical technology. The Spanish company Abengoa are building a CSP power station in Algeria, using parabolic troughs to concentrate sunlight for electricity. This technology can equally apply to other Maghreb countries. In the Mashreq, it already has powerful backers such as Prince Hassan bin Talal of Jordan. Both Africa and Europe can draw the most benefit from this by installing high-voltage direct current transmission lines under the Mediterranean, between these two continents.

Closer to home, Goodall considers developments of super-efficient buildings in Europe. He notes that only a small fraction of houses are replaced every year. To make a difference in the collective energy and carbon bills, the current housing stock needs to be upgraded, in addition to zero-emission new-builds. German ingenuity has brought about the Passivhaus (passive house) movement, which taught us that high-precision construction methods, such as prefabrication of houses, are 'the easiest way to achieve the standards' of energy efficiency required; but Goodall notes sadly that prefabrication is still 'anathema in places like the UK'. One cannot but feel that here, it is not the lack of technology that is the barrier, but sociology and politics; more on this at the end.

Unlike most commentators from the

green camp, Goodall does not treat carbon capture and storage (CCS) as a distraction from investment in real renewables, but puts it in this top-ten list. This enthusiasm relies on the premise that the carbon dioxide captured can be injected into aquifers 'to form very stable carbonates' that cannot escape. Goodall admits that this storage strategy, along with the capturing mechanism, requires more research. Indeed, any instability of storage will be the deal-breaker in the case for CCS. Still, there has been no rush on the power industry's part to invest in research and development of CCS: even the planned Kingsnorth coal-fired plant is only set to be CCS-ready, not CCS-now.

Moving from artificial carbon sinks to biosphere ones, Goodall gives zero-till cultivation 4 pages' worth of spotlight. He reports: 'Over 20 per cent of American farmlands are now avoiding the plough, and the figure is even higher in Brazil and Canada.' The late author and smallholder John Seymour argued against this practice. As he said in his classic The New Complete Book of Self-Sufficiency: 'No-diggers and no-ploughers have great success, provided they have very large quantities of compost or farmyard manure with which to mulch their land. ... The idea of very heavy mulches is fine – providing you can get the compost. But the land itself will never produce enough vegetable material to make enough compost to cover itself sufficiently deeply and therefore you will have to bring vegetable matter in from outside.'

Though the Earth is much larger than a smallholding, it is not immune from the law of the conservation of atoms. The zero-till farmlands in the Americas, if Seymour was correct, must bring in fertilizers from 'outside'. Where is this 'outside'? It is likely to be the fossil-fuel-based, carbon-intensive processes making fertilizers such as the Haber-Bosch. If true, zero-till farmlands may be devastating net carbon emitters rather than agricultural carbon sinks. This is not taken into account in Goodall's cost-benefit analysis.

Perhaps off-message for a parliamentary candidate of the Green Party of England and Wales, whose manifesto fundamentally opposes any nuclear energy, Goodall keeps an open mind about nuclear fission. Braving criticism from within his party, he hints in the Epilogue that it, along with geoengineering, might be in the running as the Eleventh Technology. But he is in no way romantic about the technology; rather, he subjects it to a detailed cost-benefit analysis. He reckons that building any new nuclear plants would only be borderline economically competitive, if at all; and it runs the risk of adversely competing with investments in real renewables. The money can be much better spent elsewhere.

Unlike Goodall's first book, How to Live a Low Carbon Life (2007), this book does not have any footnotes. Perhaps in this age of web searches, these are considered by the publisher to be devices too Victorian for a popular science book. However, the more academically-inclined reader may feel frequently frustrated that the data cited, some critical in distinguishing the usefulness of a certain technology, are not rigorously referenced.

On a more general note, shall we trust that technologies alone can save the planet? Though Goodall thinks they will play a large role, in an interview with the Environment Agency (United Kingdom) in 2007, he said, '[The different faith groups] need to form a coalition to encourage their followers to set an example to the rest of the population.' And this reviewer agree with him, who attends St Margaret's Church in the neighbouring parish in Oxford, that nothing short of precisely a collective change of heart will bring salvation.

As a popular science book, this is an exciting read that can be finished in a long weekend. Whether a lily-hearted parent worried about college fees, pension schemes and the future of generations to come, or a dyed-in-the-wool capitalist investor trying to squeeze a buck out of the climate-change lemon, this book will give the reader plenty to brood over: maybe when building a conservatory in the back of the house, or when calling the stockbroker next Monday. All the while, this book reconnects the reader to the reality of things: that there are just that many joules about – there is no way around it; and that either the carbon stays in the ground, or it goes up into the atmosphere to heat us all.

And, at the ballot box, what should be in the front of the reader's mind? At the end of the book, Goodall issues an exhortation which this reviewer wants to echo: 'We need to vote for governments that are prepared to take the somewhat painful measures, today, to permanently reduce our need for fossil fuels. Politicians who argue that climate change is too expensive to solve must be rejected – urgently.' The United States of America has done so; it is the turn of the European electorates to do the same in June 2009.

Kaihsu Tai, January 2009